**Problem Set 2. Ecosystem Energy and Water Balances NAME:\_\_\_\_\_\_\_\_\_\_\_\_**

Turn this in as a PDF of a word document including all your plots by 11:59PM **6 September, 2019.**

For this problem set we are comparing two days of data from the nearby Cumberland Plains eddy covariance tower: 04 Jan, 2019 and 28 July, 2019. These days had contrasting conditions that will help you understand partitioning of available energy. Other resources include your text and a neat animation at <https://earthobservatory.nasa.gov/global-maps/CERES_NETFLUX_M>

Step 0. Create a word document that will contain your plots and their descriptions, or save this document as a starting point for your responses. Also create and save an R script that you can use for all the calculations and plotting in this exercise.

Step 1. Calculate the average albedo as Fsu/Fsd for both days. What happens at night? Does this make sense? Consider subsetting your data! Describe the patterns in a few sentences: Why could it differ between summer and winter?

Step 2. Calculate the net radiation from the component radiation as Fnet = (Fsd+Fld)-(Fsu+Flu).

1. Plot Fnet and the shortwave and longwave components vs. time for both days to check that your data are looking good. Export and copy your plots to your word document.
2. Plot Fnet, Fh, Fe, and Fg vs. time on one graph for each day, using a y-axis scale that allows easy comparison. Set an appropriate y-axis label and copy your plots to your word document.
3. Describe the patterns you see in plots from 2a and 2b. In words, compare the components of the radiation and the individual energy fluxes (Fnet, Fe, Fh, Fg) between summer and winter. Which components change a lot, and which don’t? What happens at night?

Step 3. Energy and water flux conversions

1. Show how LE (W m-2) can be converted to ET (mm/day) with the information in note 1. Use pen and paper to demonstrate the unit conversion from energy to length units; take a photo of your dimensional analysis and insert that into your word document.
2. Calculate ET from LE in your R dataframe. Note, the units are mm/day, but you can calculate it for each 30-min period (mm per half hour).
3. What is the total water loss for each day in mm? How does this compare with restricting your ET estimates to daytime data only? What factors might explain the differences in ET between the two dates?

Step 4. Write a 200-word essay on what you learned. What might happen in a warmer, drier climate or during a heat wave?

**NOTES**:

1) To convert LE to ET, remember at 20°C, is 2.45 MJ/kg. In other words, 2.45 MJ are needed to vaporize 1 kg or 0.001 m3 of water. Assume 1 m2 basis, and density of water of 1000 kg/m3. Also remember 1W = 1 J/s

2) To convert from umol to grams, remember that 1 umol CO2 = 12\*10-6 grams C, and there are 60 seconds in a minute, 60 minutes in an hour, and 24 hours in a day.

**Table showing abbreviations and units**

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| Abbr | Variable details | Units |
| Fe | Latent heat flux | W m-2 |
| Fg | Soil heat flux | W m-2 |
| Fh | Sensible heat flux from virtual heat flux | W m-2 |
| Fsd | Solar downwelling radiation | W m-2 |
| Fsu | Solar upwelling radiation | W m-2 |
| Fld | Longwave downwelling radiation | W m-2 |
| Flu | Longwave upwelling radiation | W m-2 |
| NEP | Net ecosystem productivity | umol m-2 s-1 |
| GPP | Gross primary productivity | umol m-2 s-1 |
| ER | Ecosystem respiration | umol m-2 s-1 |
| RH | Relative humidity | % |
| Ta | Air temperature | C |